

Spinturnix vespertilionis (Dufour). This small Mite was present on the wing-membrane of *Rhinolophus ferrum-equinum*, and was identified by Professor E. Trouessart, of Paris, to whom Mr. Hirst had kindly forwarded my specimens.

REFERENCES.

- (1) COWARD, P. Z. S. 1906, pp. 849-855.
- (2) OLDHAM, Zoologist, ser. 4, vol. iii. pp. 471-474 (1899).
- (3) MILLAIS, Mammals of Great Britain and Ireland, vol. i. p. 27.
- (4) OLDHAM, Manchester Memoirs, vol. xlix. no. 9, pp. 6-7 (1905).
- (5) MILLAIS, *op. cit.* vol. i. plate 1.

3. Notes upon the Anatomy of a Species of Frog of the Genus *Megalophrys*, with references to other Genera of Batrachia. By FRANK E. BEDDARD, M.A., F.R.S., Prosector to the Society.

[Received March 19, 1907.]

(Text-figures 92-100.)

I possess, through the kindness of Dr. Charles Hose of Borneo, an example of a Frog from that country, which at first appears to be referable to the genus *Megalophrys*, and which at least comes nearest to—if it be not identical with—*Ceratophrys nasuta* of Schlegel. It appears to differ, however, from that species in one very important point and in one or two features of minor importance. The single example was in an excellent state of preservation, and I am therefore able to contribute some facts to the anatomy of this genus, which, save for many external characters and certain osteological features, is apparently quite unknown to zoologists. It is necessary, however, to preface my account of its anatomy with an attempt to fix accurately the species to which this account refers. The species *M. nasuta* was originally named and figured by Schlegel*. Our subsequent knowledge of the external characters of the species is chiefly due to Cantor†, Duméril & Bibron‡, Günther§, Boulenger||, who has summed up and added to the previous descriptions, and, latest of all, Werner¶. Darwin** has figured the heads of *Megalophrys*

* Handl. Dierk., Atlas, pl. iv. fig. 72. The leaf-like appendage upon the nose is represented as being directed forwards, which is not the case with my example.

† Catalogue of Reptiles inhabiting the Malayan Peninsula &c. Calcutta, 1847, p. 140.

‡ Erpétologie Générale, vol. viii. p. 456.

§ The Reptiles of British India. Ray Soc. 1864, p. 413; Ann. Mag. Nat. Hist. (4) xi. p. 419.

|| B. M. Cat. Barrach. Sal. 1882, p. 443.

¶ "Reptilien und Batrachier aus Sumatra." Zool. Jahrb. (Abth. f. Syst.) xiii. p. 498.

** Descent of Man, 1871, ii. p. 26, fig. 32.

nasuta and *M. montana*, regarding them, in accordance with the first and erroneous view of Günther, as male and female respectively of *Megalophrys montana*. Edeling* has figured the entire animal from above. All of these descriptions, with the exception of that of Boulenger, leave a good deal to be desired in point of details of importance, doubtless because those details were hardly appreciated as important at the time the papers or works in question were written. To Mr. Boulenger's definition, Werner has added a more accurate account of the dermal ossifications, the mere occurrence of which was known to his predecessors. I shall have occasion to refer again to all the above-named writers in the following statement of certain differences which the Frog studied by me shows as compared with *M. nasuta*.

The length of the Frog which forms the subject of the present communication is 135 mm. from snout to vent, a measurement which nearly agrees with that of Werner†, whose description is not sufficiently comprehensive to allow of a confirmation of his identification. The most salient external characters which point to my Frog being identical with *Megalophrys nasuta* are, in correlation with other characters, the long palpebral horn-like appendages and the leaf-like appendage upon the snout. The tympanum moreover is concealed, and the loreal region is excavated. Furthermore, the conical warts agree exactly in their disposition with the descriptions given by Cantor, Günther, and Werner; that is to say, there are three, one on the sacrum median, and a pair anteriorly in the shoulder-region. There are, moreover, three warts upon the head, all of different sizes, arranged in a triangle, the largest occupying the apex of the triangle which is directed backwards. Edeling‡, however, whose figure of the "species" *Megalophrys chysii* is not very good, represents only the sacral wart and nothing of the kind upon the head. Those, indeed, seem to have also escaped the attention of others. No characters of value are introduced into his two descriptions of the species, and it is impossible to be certain of the identity of "*Megalophrys chysii*." The appendages over the eye and on the nose are not of course diagnostic of the genus or species; for in various Hemiphractidæ there are similar appendages, and this family is not to be confused with the Pelobatidæ. Moreover, Mr. Boulenger has recently§ removed from the genus *Megalophrys* and assigned to the allied genus *Leptobrachium*, *Megalophrys feæ*||, a species with prominent palpebral processes, the existence of which doubtless originally influenced Mr. Boulenger in placing the species in that genus. It has also the hard skin upon the back which is mentioned as being more strongly developed in

* Nat. Tijdschr. Nederl. Indië, vol. xxvii. 1864, p. 265 & plate.

† Günther also (Ann. Mag. Nat. Hist. ser. 4, xi. p. 419) speaks of the frog as 5 inches long. Flower, on the other hand (P. Z. S. 1899, p. 916), gives 90 mm. as extreme length.

‡ Ned. Tijdschr. v. de Dierk. vol. ii. 1865, p. 205, & Nat. Tijdschr. Nederl. Indië, vol. xxvii. 1864, p. 265 with plate.

§ Ann. Mus. Genova, vol. vii. p. 750.

|| *Ibi* vol. v. p. 512.

M. nasuta than in *M. montana*. In the example studied by myself, the calcified (?) area formed a continuous plate beginning immediately behind the head, but not continuous with the hardened skin lying over the head, reaching back rather beyond the anterior ends of the ilia. Laterally this area is bounded by a raised glandular fold. On the ventral side of this fold the skin is still hardened, though not so much as dorsally; and this area is again bounded by a narrow raised area quite similar to that just referred to, which separates it from the soft but tubercular skin of the belly. The inner finger is distinctly longer than the second, a character in which this species agrees with *M. longipes** rather than *M. montana*†.

It is part of the generic definition of *Megalophrys* according to Mr. Boulenger that the outer metatarsals are united. In

Text-fig. 92.



Palmar surface of hand (upper figure) and foot (lower figure) of
Megalophrys nasuta.

this it differs, according to the same author, from e. g. *Pelobates*, where the "outer metatarsals are separated by web." Having been able to compare my Frog with *Pelobates fuscus*, I find that

* Boulenger, P. Z. S. 1885, p. 850.

† Id., Cat. Batr. Sal. p. 442.

both frogs agree in the separation by web, only that the web is more extended towards the tips of the toes in *Pelobates**. In this, my species apparently agrees with *Megalophrys longipes*. It has, however, a fairly conspicuous inner metatarsal tubercle, but nowhere projecting from the surface of the foot as in *Pelobates*. I found no trace of an outer metatarsal tubercle or of subarticular tubercles. These are absent in *M. longipes*, but described (together with the inner metatarsal tubercle) as "indistinct" in *M. montana* and (by inference) *M. nasuta*.

There are other characters used for systematic purposes in which the individual which I have dissected does not agree with its presumed congeners. The vomerine teeth, which are very few† and form only a narrow band over the projecting region of each vomer, are situated distinctly to the inside of and not behind each choana. And the loreal region is deeply concave, as it is stated to be in *Megalophrys montana* and (by inference) in *M. nasuta* by Boulenger‡, but apparently not in *M. longipes*. As a part of the generic definition of *Megalophrys*, Boulenger uses the form of the tongue, which is described as "subcircular, indistinctly nicked and free behind." In my example of *Megalophrys* the tongue is very faintly§ nicked behind. It is also nearly circular and free behind.

Very important also in fixing the systematic position of this Frog are two osteological characters which have been largely used in defining the genera of Batrachia. The fusion of the sacral vertebra with the ensuing coccyx is a rare feature in Batrachian osteology. It occurs, however, in *Pipa* and among the Pelobatidæ. In two genera only, viz., *Scaphiopus* and *Pelobates*, does Boulenger describe the sacrum and coccyx as confluent. They are most unquestionably so in the Frog which I describe in the present communication, and this confluence is incidentally shown in the drawing (*cf.* text-fig. 93) on p. 332, illustrating the arrangement of certain muscles. This fusion of the sacral vertebra with the coccyx is not only an important classificatory fact if existing systems are to be respected, but raises another fact of greater importance. It is well known that among those genera of Anura in which this fusion occurs, viz. *Pipa*, *Xenopus*, and *Hymenochirus*—the entire set of genera constituting the Aglossa—and in *Pelobates*, *Scaphiopus*, and the present genus among the Pelobatidæ, and in *Bombinator* among the Discoglossidæ, the apparently single sacral vertebra is really double in the case of *Pipa* and *Pelobates*, formed of three vertebræ in *Hymenochirus*, and of only a single vertebra in *Scaphiopus* and *Bombinator*. It becomes, therefore, a matter of great interest to ascertain what is the arrangement that characterises the sacrum of the species

* Günther, Cat. Batr. Sal. 1858, p. 136, speaks of the toes of *Ceratophryne nasuta* as "completely free."

† Günther, Cat. Batr. Sal. 1858, p. 136, writes—"Vomerine teeth none."

‡ Cat. Batr. Sal. p. 542.

§ "Tongue entire behind."—Günther.

which I provisionally at least identify with *Megalophrys nasuta*. The most obvious test to apply for the solution of this question is the exit of the spinal nerves. Now I find that a stout nerve issues from the spinal cord just in front of the stout and expanded transverse process of the sacral vertebra; and that an equally stout nerve issues behind this transverse process in the angle between it and the coccyx. There is none between the two. Hence the sacrum is composed of but one vertebra as in most other Frogs.

A second character is the procœlous excavation of the vertebral centra. A part of the definition of *Megalophrys* by Boulenger is "Vertebrae opisthocœlian." This character, used by him in the tabular * discrimination of the genera of Pelobatidae, is again made use of in the fuller description of the genus *Megalophrys* †.

It is, however, in the characters of the sternum that this species chiefly differs from other species of *Megalophrys*. Among the characters used by Boulenger ‡ to define the family Pelobatidae, one is stated as follows, viz.: "The omosternum is constantly present, but small and cartilaginous." That this definition is not absolutely true was subsequently shown by Mr. Boulenger himself §, who asserted that in *Scaphiopus solitarius* there was "no omosternum." The shoulder-girdle and sternum of the genus *Megalophrys* have been figured and described by Parker || in *Megalophrys montana*. The omosternum is minute and the sternum is ossified nearly throughout, an inconspicuous cartilaginous xiphisternum only being left at the free extremity of the bone. These characters (*inter alia*) are used by Mr. Boulenger in his definition of the genus *Megalophrys*, and therefore presumably also apply to *M. nasuta*. Whether the sternal apparatus of *M. longipes* has been examined I do not know. In the Frog upon which I report in the present communication, the characters of the sternal apparatus are different from those which have been referred to in *Megalophrys montana*. Both sternum and omosternum are very well developed.

The omosternum, instead of being a small oval plate of cartilage as it is represented to be by Parker in *Megalophrys montana*, has a form which apart from details is more like that of *Rana esculenta*. It is actually ten millimetres long, and its proportions to the rest of the sternum are therefore much more like those of *Paludicola bibronii* figured by the same author ¶. Although, as in *M. montana* and other Frogs, the procoracoids are bent very

* Cat. Batr. Sal. 1882, p. 433.

† *Ibid.* p. 442.

§ P. Z. S. 1899, p. 790.

|| A Monograph on the "Structure and Development of the Shoulder-Girdle," Ray Soc. 1868, p. 78, pl. vii. fig. 8.

¶ It is by no means certain in every case that the species described by Prof. W. K. Parker in his Monograph of the Shoulder-Girdle have been correctly identified. I find for example that the sternum of *Hyla cœrulea* (= "*Calamites cyanea*" of Parker's nomenclature) is not as Parker has figured it (*loc. cit.* pl. vii. fig. 6), but exactly resembles the sternum of "*Aerodytes daudinii*" (presumably a *Hyla*) figured by the same author (*loc. cit.* pl. vii. fig. 1).

‡ *Loc. cit.* p. 432.

much forwards, their articulation with the omosternum in *M. nasuta* is not by any means so far forwards as it is figured by Parker in *M. montana*. This articulation is plain enough in *M. nasuta*. Above this articulation and for the entire shaft the omosternum is clearly calcified. It expands above into a circular cartilaginous plate which has a crescentic outline anteriorly and is wider than the shaft. The procoracoidal cartilages at and near both points of articulation with the omosternum are also calcified. The sternum consists of a bony style as in *Megalophrys montana*; but there are differences in detail. In the first place, the bone is longer in proportion to its width in *M. nasuta*, and it does not expand so markedly in width towards its posterior termination as is represented in Prof. Parker's figure of *Megalophrys montana*. In the second place, *M. montana* is characterised by a cartilaginous xiphisternum which "is but little extended either laterally or axially beyond the shaft-bone." This is not at all the case with *Megalophrys nasuta*, where the xiphisternum is a broad and expanded plate, having posteriorly the semicircular cheese-cutter-like outline which is so usual among Frogs. On the whole, therefore, there are some differences between the two species.

The sternum of this Frog is in fact particularly large as compared, for example, to that of its ally *Pelobates fuscus*, with which I have compared it in this and in some other details of structure. The difference of size is, of course, actual in view of the much larger dimensions of the Frog which I describe here as compared with the rather small *Pelobates fuscus*. In *Pelobates* the total length of the body in the individual measured was 47 mm. and the total length of the sternum 16 mm., the sternum being therefore roughly one-third of the length of the body. The corresponding measurements in the Frog described here were 135 mm. and 60 mm., the proportions therefore nearly approaching one-half. The relationship of the sternum to the underlying viscera shows corresponding differences in the two genera. In *Pelobates* the sternum hardly extends back beyond the heart and pericardium which, however, it fully covers. The liver is left largely exposed. In "*Megalophrys nasuta*" the sternum passes a considerable distance beyond the liver-lobes, the heart being beneath almost the commencement of the sternum proper.

So far as I can gather from the memoirs already quoted which deal with the species *Megalophrys nasuta*, there has been no actual description of the sternum in this particular species. But since several systematists use the occurrence of a rudimentary omosternum as a generic definition, the matter must have been looked into by them, or by some of them. So far as present views upon the classification of the Anura go, it is clear that I should be hardly wrong in instituting not merely a new species but a new genus for this Frog, on account of its divergent sternal characters, as compared with those that have already been described in the genus *Megalophrys*. In contradiction, however, to this

conclusion is the extraordinary similarity in detail—I particularly recall the three warty tubercles upon the back and the “nose-leaf”—between this species and *M. nasuta*; but coupled with these are also, as it would appear, differences in features of similar or nearly similar value. Thus the species described here differs from *M. nasuta*, in that the vomerine teeth are within a line joining the choanæ, and that the inner finger is distinctly longer than the second. Again, however, I infer these differences, being unable to find any definite description of the characters in *Megalophrys nasuta*.

The above statement concerning those characters used in the discrimination of genera and species among the Anura seems to me (unless very grave errors have crept into existing descriptions) to show that quite possibly two species have been confused under the name of *Megalophrys nasuta*, which may even be legitimately referred to different genera. I do not propose, however, for the present to give a name to the species the anatomy of which I deal with in the following pages, in case systematists have really had before them, and described, a Frog which is identical with it. But even in this case the foregoing description of external characters is not without use; for some of these characters have been undoubtedly overlooked, or imperfectly described, as in the case of the sternum.

The above account of the systematic characters of the Frog which, on a superficial examination, would be referred to *Megalophrys nasuta* as described by Cantor, Günther, Schlegel, and Werner, and, I presume, Boulenger*, may be conveniently summarised for future reference. The following is a restatement of the characters of *Megalophrys nasuta* based upon the single female example of a Frog from Borneo, which, from a survey of the external characters as described by several zoologists, would be referred to that species;—

Length about 5 inches. Head broad and depressed, with loreal region excavated. Tympanum invisible. Long palpebral process over each eye and an upwardly directed leaf-shaped process on the snout. Vomerine teeth few, between choanæ. Tongue sub-circular, very faintly nicked, free behind. Teeth only on upper jaw. Three inequized warts forming a triangle upon posterior region of head. Skin of back indurated, like that of head, to a point behind front ends of ilia. This region separated by a narrow glandular fold from lateral region, also, but more slightly, indurated, which is again separated by a similar fold from the warty ventral surface. Three prominent tubercles upon back, one

* Mr. Boulenger's recent description (Ann. Mus. Genov. ser. 2, iv. p. 512) of a Frog, referred to the genus *Megalophrys*, and to a new species of the same, viz., *M. fee*, which was later (*ibid.* vii. p. 750) removed by him to the genus *Leptobrachium* (with which he also fused the genus *Xenophrys*), seems to show that Mr. Boulenger had not before him at the time when he wrote his ‘Catalogue of the Batrachia Salientia’ examples of the Frog described by myself in the present communication. For he has mentioned in describing “*Megalophrys*” *fee* the fact that the vertebrae are procelous and that they are opisthocelous in *Megalophrys nasuta*.

on each shoulder and one on sacral region. Vertebrae procœlous; sacral vertebra fused with coccyx, its transverse processes greatly expanded. No ribs. Omosternum not rudimentary, with calcified style; sternum a bony style, with expanded cartilaginous xiphisternum; shoulder-girdle arciferous. Fingers free; inner finger longer than second. Toes half-webbed; outer toe separated from next by web. Toes not dilated at tips; no articular tubercles; inner metatarsal tubercle extensive but not separated anteriorly from the surface of the foot; no outer metatarsal tubercle.

Hab. Borneo.

It will be observed that in the above brief diagnosis I have not attempted to differentiate between generic and specific characters or indeed family characters. That this Frog belongs to the Pelobatidæ is quite plain. That it cannot be referred to any known genus—if the present definitions of the same are retained—is also obvious*. I propose, however, for the present to defer the question of generic distinctness until the Pelobatidæ are better known anatomically†.

Whether this Frog is a new species or identical with *Megalophrys nasuta* I must, for reasons already stated, leave uncertain.

§ *Muscles of the Back.*

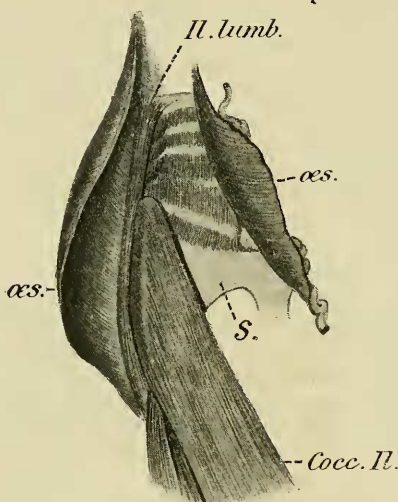
In the various drawings (text-figs. 93–96) submitted herewith in illustration of the diaphragm of different species of Batrachia, the principal muscles of the back are also shown, and it will be at once seen that these differ considerably in the different forms. Only in *Megalophrys* is it impossible to see these different muscles (text-fig. 98), for the lengthy transverse muscle of the œsophagus and lung almost completely covers them over. When, however, this muscle is divided along its greater length, *i. e.* across the direction of its fibres and the two flaps reflected, the muscles now in question are fully displayed as shown in text-fig. 93. The same muscles are present which are known to exist in *Rana esculenta*, with the possible addition of a muscle not found either in *R. esculenta*, *R. guppyi* (see p. 333), or *R. tigrina*, of which species I have examined the last two. The *Intertransversarii* muscles are well developed and commence from the anterior margin of the greatly expanded transverse process of the sacral vertebrae. They are so well developed that they almost conceal the anteriorly lying transverse processes of the vertebrae, each separate band of muscle joining successive transverse processes being attached near to the ventral median line of the same. The *Ilio-lumbaris* muscle

* (Footnote added May 8th.) After the reading of this paper, Mr. Boulenger kindly drew my attention to the fact that there occurs in *Pelobates cultripes* a variation in connexion with the fusion or non-fusion of the sacral vertebra with the coccyx ('The Tailless Batrachia of Europe,' Ray Soc. 1897, part i. p. 208). It does not, however, follow that if a character is variable in one species it is not a "good" character in another.

† Schlegel's name *Ceratophryne* cannot be resuscitated; for he first applied it to *C. dorsata*, an American frog which is, I presume, *Ceratophrys dorsata*.

is comparatively unimportant, when those muscles in some other Frogs to be shortly described are considered. As shown in text-fig. 93 its branches to the transverse processes are limited to the outer edges of these. The enormously expanded sacral vertebrae which overlie the ilia give off anteriorly the strongest slip of muscle which I refer to the *Ilio-lumbaris** complex. A slender slip of muscle represents the origin of the muscle from the ilium. This arises from the tip of the ilium as it has been described to arise in *Rana esculenta*; but instead of running forward as in

Text-fig. 93.

Part of dorsal musculature of *Megalophrys nasuta*.

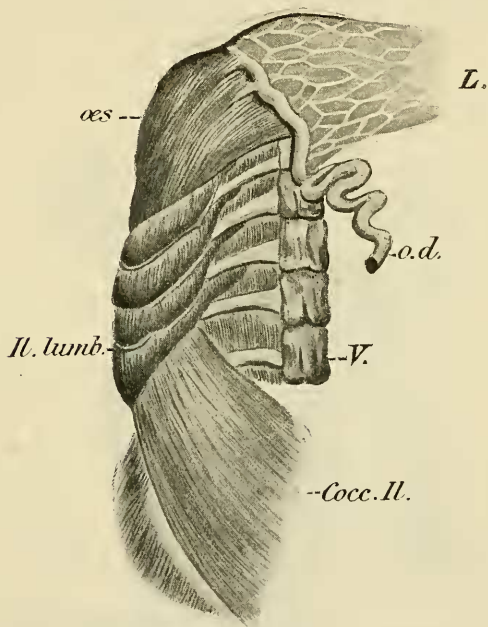
æ.s. Esophageal muscle cut and reflected with oviduct. *Cocc. Il.* Ilio-coccygeal. *Il. lumb.* Long slip of Ilio-lumbaris muscle compared in the text with the *Musculus proprius pulmonum* of *Pipa*. *S.* Transverse process of sacral vertebra, the fusion of which with the coccyx is shown. To the right of the long ilio-lumbar slip three short ilio-lumbaris are shown overlying the *Intertransversarii*.

that frog, it runs dorsally at right angles to the longitudinal axis of the body owing to the overlap of the sacral vertebra to which it is partly attached. *Megalophrys* differs, as will be seen presently, from a number of other Frogs in the presence of a long, almost strap-shaped and strong muscle which may perhaps be referred to the *Ilio-lumbaris* complex. This arises from the ilium a long way back and is continued straight forwards, without any insertions of detached slips on the way, to the third vertebra, to the outer

* This corresponds throughout the following descriptions to the "*Pars lateralis*" of Gaupp.

cartilaginous extremity of the transverse process of which it is attached. A flat slip of muscle connects the third vertebra with the second, and is exactly in the same straight line with the muscle just described. It gives the impression of being a portion of it although it is not actually connected. There is nothing exactly comparable to this muscle in any of the genera of *Batrachia* with which I shall presently deal, with the exception of the allied *Pelobates*. I am inclined, however, to think that it may be the homologue of the "musculus pulmonum proprius" of *Pipa**, which the enormous growth of the transversalis in *Megalophrys* has cut off from communication with the aponeurosis of the lung and diverted to the transverse processes of adjacent vertebrae. But this is at present no more than a suggestion.

Text-fig. 94.

Some of the dorsal muscles of *Rana guppyi*.

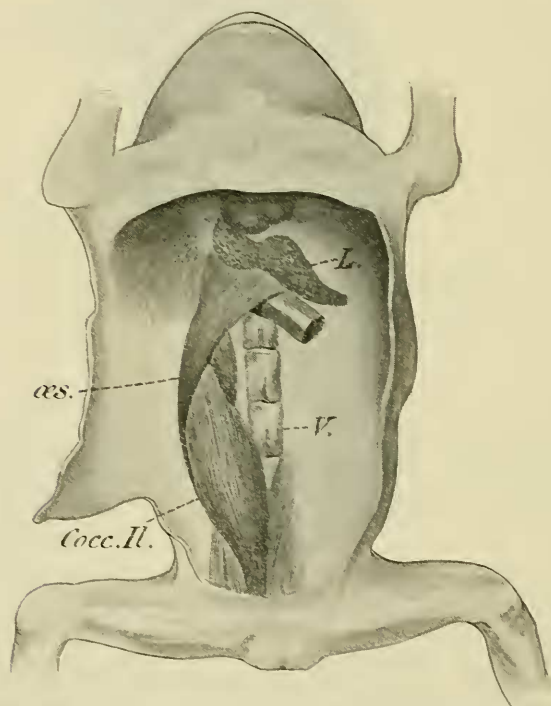
L. Lung. o.d. Oviduct. V. Vertebral centra. Other lettering as in text-fig. 93.

A comparison between the muscles of *Megalophrys* which have just been described and those of *Rana* shows a great number of differences. In *Megalophrys* the Ilio-lumbar muscle complex is

* Beddard, P. Z. S. 1895, p. 830, fig. 1 m. The transversalis sheet to the lung is not shown in this figure, but is in that of Keith (J. Anat. Phys. xxxix. p. 257, fig. 13 c).

not important as compared with the *Intertransversarii*, that is if the long muscle running from the ilium directly to the third vertebra be put out of consideration. In *Rana guppyi* on the other hand (see text-fig. 94) the ilio-lumbar muscles are very important and occupy a considerable space upon the transverse processes of the ribs. The whole muscle appears to be continuous from the top of the ilium to the transverse process of the vertebra. But it is, though strictly continuous, interrupted by tendinous intersections, each one of these corresponding to a transverse process. These tendinous intersections are of some width. In *Rana tigrina*, which I have been able to compare, the muscle has the same general arrangement: but the tendinous intersections are hardly noticeable. This difference is very possibly merely one of those differences which may be fairly put down to size. In the larger *Rana guppyi* the complication of the muscle is greater than in its smaller ally.

Text-fig. 95.



A dissection of *Pelobates fuscus*, to show large oesophageal sheet of the transversalis. Lettering as in text-figs. 93, 94.

Pelobates shows a distinct likeness to *Megalophrys* in the disposition of the muscles now under consideration, as might be

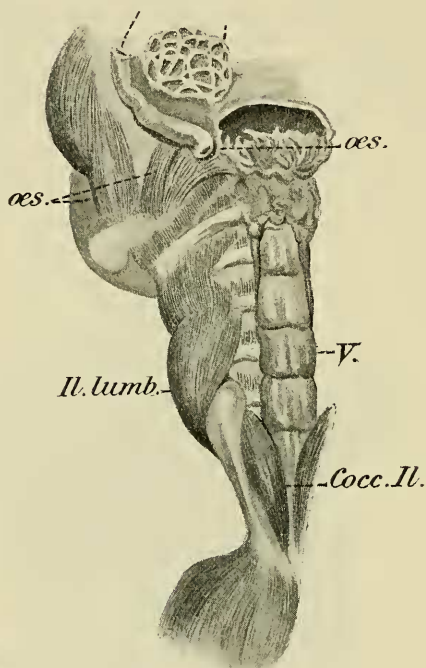
expected from other points of likeness between the two genera, which are referred by some systematists to the same family of *Arceifera*. The striking feature about the muscles of this region of the body in *Pelobates*, is their very massive development as compared more particularly with *Bufo* and *Ceratophrys*, which I shall deal with later on in this communication. When the viscera are pushed to one side to render visible these various muscles, the ilium and the transverse processes of the vertebrae are nearly completely invisible. The latter indeed are entirely so; but a portion of the ilium is exposed where the massive ilio-coccygeal muscle diverges from it. This is by no means the case with other genera, as the series of figures (text-figs. 93-96) illustrating these facts shows. In this feature again *Megalophrys* comes nearer to *Pelobates*. But in *Megalophrys* the expanded sacral vertebrae are left uncovered; they are quite covered in *Pelobates*.

The strong *Ilio-coccygeal* muscle covers nearly the whole of the ilium, arising up to its very tip. To the inside, *i. e.* towards the centre of the vertebral column, it conceals the commencement of the *intertransversarius*. The latter muscle is also very strong and thick. Instead of lying between adjacent transverse processes, it is not on their plane at all, but entirely covers them and moreover shows no visible tendinous inscriptions. Quite anteriorly at the second or third vertebra, this muscle finally meets the equivalent of the peculiar muscle described above in *Megalophrys*. That muscle, as in *Megalophrys*, arises in *Pelobates* a long way down the ilium; it is strap-shaped, but relatively stouter than in *Megalophrys*. In front of the ilium it had no attachment to—sent down no slips to—the transverse processes of any vertebrae save the anterior vertebra to which it is ultimately attached. I could detect no *ilio-lumbaris* other than this muscle, even on removing it from its close contact with the *intertransversarius*; nor indeed is there much room for one.

So far as the material upon which I am able to report here enables me to say, *Ceratophrys* stands at one end of a series commencing with *Pelobates*, and of which *Rana* is an intermediate member in so far as concerns the muscles of the back which are here dealt with. In *Ceratophrys* the muscular development of this region of the body is but feeble, relatively speaking. The transverse processes of the vertebrae and the larger part of the ilium are quite uncovered by muscles, which are extremely shrunken as compared with those of *Megalophrys* and *Pelobates* and even *Rana*. The same muscles precisely can be recognised and with but little modification. The *Ilio-coccygeal* is much reduced and arises only from the internal edge of the ilium, commencing some way below the tip of that bone and not extending on to the ventral side. The *Intertransversarii* are quite separated by the successive transverse processes. There is no continuous band of musculature as in *Pelobates* and, though to a less extent, in some of the other types described here. The *Ilio-lumbaris* is peculiar as compared with that of other genera: it arises as a thick band of muscle from

near to the tip of the ilium. It forms a continuous mass without tendinous intersections, giving off, however, slips to three transverse processes only, upon the most anterior of which the muscle ends.

Text-fig. 96.

Some of the dorsal muscles of *Ceratophrys ornata*.

Lettering as in text-figs. 93 & 95.

In *Ceratophrys* the vertebræ thus supplied by branches of the ilio-lumbaris muscles are Nos. 5, 6, 7; but a few fibres are seen to run on to the transverse process of the fourth vertebra.

Bufo closely resembles *Ceratophrys* in all these features. The ilia and the transverse processes of the vertebræ are but little covered with muscle—at any rate in *Bufo marinus* and *B. agua*, the two species studied by myself. The ilio-coccygeal is, in precisely the same way, a much reduced muscle, commencing its origin some way back upon the ilium and not extending upon the ventral surface of that bone. The ilio-lumbaris is if anything a rather slighter muscle than that of *Ceratophrys*. Otherwise it is exactly similar in its appearance and relations to *Bufo marinus*

(I am not quite certain as to *B. aqua*); its fibres are inserted on to the transverse processes of vertebræ 4 to 7 inclusive. It is from the fourth vertebra in these species that the œsophageal and lung muscles arise (see below, p. 346). In *Rana* also it is from the fourth vertebra.

The resemblance between *Bufo* and *Ceratophrys* in the muscles now under consideration, particularly in their feeble development as compared with the corresponding muscles in some other genera, might be put down to similarity of habit. For *Ceratophrys* is emphatically a 'toad' in its terrestrial habits and lethargic life. I find, however, that there is a close likeness in respect of these various structures between *Ceratophrys* and *Leptodactylus* which is important in view of their inclusion in the same family Cystignathidæ by some systematists. I have examined two individuals of *Leptodactylus hexadactylus*, which agree entirely in all the structural features to be referred to immediately. A considerable portion of each ilium is left perfectly free of muscle. As in *Ceratophrys*, but not in *Bufo*, the anterior extremities of the ilia do not reach as far as the transverse process of the eighth vertebra; they extend beyond them in *Bufo*. The ilio-coccygeal commences some little way down the ilium and gives off slips to the transverse processes of vertebræ 4 to 8 inclusive, and the origin of the lung-muscle is confined to the fourth vertebra.

There is not, in fact, much difference in these particulars between *Leptodactylus* and *Rana*. For though in the large *Rana guppyi* the ilium is well covered by the ilio-coccygeal muscle, this is not the case with *Rana tigrina*. And the well-marked tendinous intersections of the muscle in the larger *Rana* are not seen in the smaller species, which thus resembles *Leptodactylus*. In *Ceratophrys* the modifications as to these muscles have gone still further, and it is perfectly clear from the figures (text-figs. 94, 96) that that genus shows marked, though in reality superficial differences from other Frogs, which may perhaps, in view of its likeness to *Bufo*, be looked upon as adaptive. It is, however, perfectly clear that *Megalophrys* and *Pelobates*, though differing from each other in various details, are on the whole much more different from the other genera treated of here than are any of those genera among themselves.

§ *Muscles of the Ventral Surface.*

In the sternal region of *Megalophrys nasuta* the following muscles are displayed when the skin is removed:—(1) *Pars abdominalis of Pectoral*; (2) *Pars sternalis of Pectoral*; (3) *Pars epicoracoidalis of Pectoral*; (4) *Pars episternalis of Deltoid*; and (5) *Pars scapularis of Deltoid*. As contrasted with *Rana*, the most salient difference shown in this dissection is the very large size of the episternal head of the deltoid, which is as large as, and of course longer than the scapular portion, and together with the epicoracoidal head of the pectoral completely hides from view the

coraco-radialis. The latter is fully exposed in *Rana* owing to the slenderness of the slip, which represents in that Frog the very large pars episternalis deltoidei of *Megalophrys*.

The *Coraco-brachialis brevis* seems to be exactly as in *Rana*. The coraco-brachialis longus is a double muscle, exposed only by cutting the pars sternalis of the pectoral.

I could not find the pectoro-cutaneous muscles which are so conspicuous in the large *Rana guppyi*.

Rectus abdominis.—This muscle arises precisely as in *Rana* from the pelvis, and has here the same conical form, expanding as it does rapidly from behind forwards. Between the two Recti lies the anterior abdominal vein, which is evident until it dips beneath the backwardly prolonged sternum in front. The rectus abdominis has only four *Inscriptiones tendineae*. Three of these lie behind the posterior end of the sternum. The fourth lies beneath the expanded xiphisternum, covered by it, that is to say, when the frog is viewed from the ventral aspect. In *Rana temporaria* there are five of these transverse septa, between the several sections of the muscle. Anteriorly to the first inscriptio tendinea the main mass of the muscle passes without a break, as in *Rana*, into the *sterno-hyoid*. A portion of the rectus muscle, however, just anterior to the origin of the pectoralis abdominalis and largely covered by the obliquus, is separable by a distinct gap and lies at the outside of the main mass of the rectus. This muscular slip ends in a strong tendon which is attached to the rhomboid swelling of the sternum and seems even to reach the coracoid beyond it.

The *Sterno-hyoideus* is rather more complicated than in *Rana*. It is first of all found as the forward extension of the rectus abdominis. From the expanded xiphisternum—from its anterior edge—a flat band of fibres runs forward which dip under the tendon of the sternal insertion of the rectus and join the main mass of the sterno-hyoid. There is a third origin of this muscle from the concealed (dorsal) surface of the sternum. The fibres of this muscle arise from further back along the sternum almost from the very extremity of the expanded xiphisternum. The more anteriorly arising fibres form a separate muscle, distinguishable even by a lighter colour, which runs along the inside of the main body of the sterno-hyoid. The insertion upon the body of the hyoid is more extensive than in either *Rana* or *Pelodytes*. The insertions of the two muscles are in contact in the middle line of the cartilage and they extend further anteriorly.

§ *Hyoid and its Musculature.*

The *Hyoid and its musculature* are in some ways peculiar in *Megalophrys nasuta* as compared with those of other Batrachia. On opening the body-cavity, a strong pillar of muscle is seen anteriorly resting on the pharynx on either side. This is the ceratohyal with the enveloping hyoglossal muscle. In *Rana* the

ceratohyal is a continuation on the same plane and in the same straight line of the rest of the hyoid. In *Megalophrys* this part of the hyoid arch is bent down at nearly a right angle with the rest of the hyoid. The close connection of the bone and its ensheathing muscle with the pharynx led me to assume at first an actual anatomical connection between the two. A careful examination, however, shows that there is no such connection, and that the hyoid with the muscle can be raised up from its position which is in actual contact with the pharynx. It is even possible that pressure may be exerted upon the pharynx by the muscle. In the second place, this hyoglossal muscle is very much thicker and altogether stouter than the same muscle in the very much larger frog *Rana guppyi*. As in *Rana*, the two halves of the hyoglossal muscle fuse and become one, and this is continued forward in close contact and on the median line of the hyoid to the tongue.

The *Submentalis* has the usual positions and relations. What is remarkable about it in the present species is that it is actually (and therefore *a fortiori* relatively) larger than the same muscle in *Rana guppyi*.

The *Petrohyoidei* are, as in *Rana esculenta**, four in number. As in that frog, the petrohyoideus of *Megalophrys*, arising also from the body of the hyoid, is larger than the three following divisions of the muscle which spring from the bony thyrohyals. The last of these in *Megalophrys* is a large fan-shaped muscle which is not so very much smaller than the anterior petrohyoid. And, moreover, the three divisions of this posterior petrohyoideus muscle are all of fair size, and not merely in contact at their origins (which they are not in *Rana esculenta*), but the middle one actually overlaps the other two. It is important to note that in *Pelodytes punctatus*, according to Ridewood†, the fourth division of the petrohyoid is absent.

The third division of the *Petrohyoideus posterior* arises, it may be remarked, from the inner edge of the thyrohyal and not as the other two from or near the outer edge of this bone, *i. e.*, that facing towards the attachment of the muscles. In *Rana*, Gaupp describes the muscle in question as springing from the cartilaginous epiphysis of the thyrohyal. This is not at all the case with *Megalophrys*, where the epiphysis in question, easily detached, is a relatively long and spur-like plate of cartilage directed outwards and at right angles to the shaft of the thyrohyal. The anterior of the three posterior petrohyoids does not arise from the bony thyrohyal, but from the cartilage at its junction with the body of the hyoid.

The *Omohyoid* appears to show no peculiarities as compared with *Rana*.

The *Geniohyoid* has the usual two origins, and it is to be noted that these are as in *Pelodytes* according to Ridewood, and not as

* Gaupp's edition of Ecker's 'Anatomie des Frosches,' 1896, p. 139.

† P. Z. S. 1897, p. 579.

Rana according to the same observer; that is to say, its origin does not extend on to the tough membrane which lies between the posterior process of the body of the hyoid and the thyrohyal. Nor, in *Megalophrys*, as again in *Pelodytes* but not in *Rana*, is any part of the sternohyoid inserted on to this membrane. The reason for this is clear in the case of *Megalophrys*. For in that Frog the very large posterior petrohyoid completely covers over this space and would allow of the insertion of no muscle upon it.

The *Subhyoideus* (the posterior portion of the submaxillaris of some authors) is rather different in the Frog which forms the subject of the present communication from the corresponding muscle of *Rana*. In the latter it is a hyoidean muscle and arises in the extreme lateral region of the hyoid cornua. In *Megalophrys*, where these cornua are absent, I traced the muscle to the wall of the skull just behind the tympanum.

The *Hyoid cartilage* is not like that of either *Pelodytes* or *Pelobates*, both of them allies of the present genus. Nor does it recall that of *Rana*, for I can find no trace of a cartilaginous cornu principale or hyoid arch proper; and as I have already stated, the subhyoideus muscle arises from the skull-wall and did not serve to guide me to a hyoid bar.

Xenophrys monticola obviously comes nearer to my species than any other species of the hyoid of which I can find a description. Of this Frog the late Prof. W. K. Parker wrote*: "I could find no cartilage in the hyoid arch from the Eustachian opening downwards until I reached the hypohyal region." The outline is very similar to that of *Megalophrys nasuta*. There is towards the upper end of the diverging body of the hyoid (the hypohyal of Parker) a nick in the cartilage on the outer side. This, as I think, represents the nick which I figure here in *Megalophrys nasuta*, and to which what appear to be vestiges of the hyoid arches or ceratohyals are attached. Behind this in *Xenophrys monticola*, as in *Megalophrys nasuta*, the body of the hyoid forms a bay from which arises in my species the anterior petrohyoideus. There is no more trace in *Xenophrys* than in my species of an anterior lateral process of the body of the hyoid, unless indeed the hypohyal really represents that, and the true anterior process of the body of the hyoid is absent. In both these Frogs, however, the posterior lateral process of the hyoid is present, and the thyroid bar is well-developed and ossified, but without the spur-like cartilaginous epiphysis of *Megalophrys nasuta*.

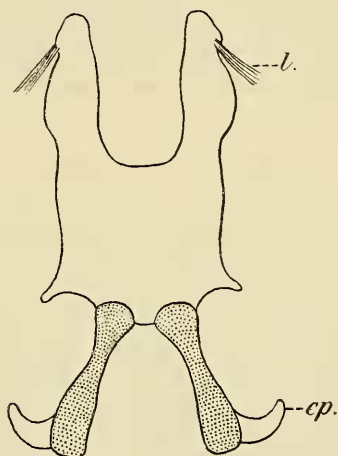
The accompanying figure (text-fig. 97) shows the hyoid of *Megalophrys nasuta*. The body is fairly stout and shows no traces of an anterior lateral process. The anterior, "hypohyal," process on each side is a somewhat spoon-shaped piece of cartilage in the same straight line with the rest of the body of the hyoid. It is not bent inwards as in *Pelobates* and *Pelodytes*†. Nor could I

* "The Skull in the Batrachia," Phil. Trans. 1881, pl. 23, fig. viii.

† P. Z. S. 1897, pl. xxxv. figs. 10, 12.

find any foramen in the cartilage such as occurs in *Pelodytes*. There was a slight thinning, however, of limited extent at a point just opposite to the divergence of the two anterior prolongations of the body of the hyoid, and corresponding therefore to the marked foramina shown in the two genera *Pelodytes* and *Pelobates* by Dr. Ridewood, whose figures are referred to below, and in *Scaphiopus**. If that be so, it would seem to follow that the tract of cartilage lying outside of this is really the remains of the hyoidean cornu, and the apparent solidity of the body of the hyoid due to the complete and secondary fusion of this hyoidean cornu with the body of the hyoid. The weak place in the body of the hyoid is, however, so little marked that I hesitate to give to it this morphological importance, and, moreover, it is covered by

Text-fig. 97.

Hyoid of *Megalophrys nasuta*.

cp. Cartilaginous epiphysis. l. Ligament representing anterior cornua.

the attachment of the sterno-hyoideus muscle which lies to the inside of the foramen in *Pelodytes punctatus*. More likely to correspond to traces of the otherwise missing hyoidean cornu is, I think, a stout ligament shown in my figure (text-fig. 97) which is attached to a slight indentation near to the anterior end of the anterior prolongation of the body of the hyoid. The position, it will be observed, is by no means unsuitable to such an interpretation of its nature. Nor would this argument be necessarily at variance with the supposition that the thinning on the body of the hyoid in this frog is the equivalent of the foramen in *Pelodytes* and

* Boulenger, P. Z. S. 1899, p. 792.

Pelobates. I could find no splint-bone, such as Ridewood has figured in *Pelodytes* as lying upon the posterior edge of the body of the hyoid among the fibres of the sterno-hyoid muscle whose insertion reaches quite to this edge. The body of the hyoid contained no ossified tracts such as are sometimes met with in this cartilage in other Frogs. The strongly ossified thyrohyals lie, as already mentioned, at a considerable angle with the body of the hyoid. The cartilaginous epiphysis of the same is not a cap at the free end, but is attached to the outer edge and is somewhat curved. It suggests a separate but rudimentary upper element of this branchial arch—if it really be one, and not a mere process of the body of the hyoid. Dr. Ridewood quotes Mr. Boulenger's opinion "that the hyoidean cornua were disjointed in all those genera which he includes in the family Pelobatidæ."* My own results do not enable me to support fully this assertion. I would rather say that among the Pelobatidæ the hyoidean cornua are clearly on the road to disappearance. Dr. Ridewood has pointed out several points of likeness between these structures in the *Aglossa* and in the Pelobatidæ. I may add that the disappearance of the anterior cornua in *Megalophrys nasuta* and *Xenophrys monticola* is also to be observed in *Pipa*.

§ *Muscles of Shoulder and Arm.*

The muscles arising from or inserted into the scapula appear to be the same in *Megalophrys* as in *Rana*; for I identified the following, viz.:—*Dorsalis scapulae*, *Rhomboideus anterior*, *Rh. posterior*, *Levator scapulae superior*, *L. s. inferior*, *Cucullaris*, *Serratus superior*, *S. medius*, *S. inferior*, *Interscapularis*, and *Omo-hyoideus*; besides others of which a further account seems to be desirable. There are two of these, viz., the *deltoid*, and a muscle of which I find no account in Gaupp's edition of Ecker, and which I term *scapulo-humeralis*. I have already referred to the pars episternalis of the deltoid. The only further point to be remarked upon is the apparently total absence of a clavicular head, which head I found to be very conspicuous in the large *Rana guppyi*.

The *scapulo-humeralis* is a small slender muscle running from the scapula to the neck of the humerus, between the scapular and adjoining humeral heads of the anconeus. I found this muscle in *Rana guppyi*.

§ *Muscles of Thigh.*

The thigh-muscles of *Megalophrys* are in many respects different from those of *Rana*.

The most salient difference is seen on the inside of the thigh when the skin is removed, and concerns the *Semitendinosus*. This muscle is then evident without further dissection, and is not at all covered by the two *Graciles*. The tendon of insertion of these two latter muscles in fact, instead of passing over the tendon of

* Journ. Linn. Soc. vol. xxvi. p. 53.

the semitendinosus (that is of course when the thigh is inspected from the inside), passes below it. The arrangement is thus the precise reverse of that which characterises *Rana*.

The *Semitendinosus* is then quite a superficial muscle on the inside aspect of the thigh, visible for practically its whole extent without dissection. In *Rana* it is covered not only by the graciles but by the adductor. The semitendinosus may be termed a two-headed muscle, but there are traces of further subdivision at the origin from the symphysis. The lower (posterior) half of the muscle arises by two closely contiguous heads and is to some extent overlapped by the gracilis major. It ends at about the end of the second third of the femur in a stout tendon which is continuous with the insertion on to the inside of the leg below the knee. The anterior half of the muscle is inserted on to this tendon soon after it is established. There is no common fleshy origin with any part of the adductor mass such as occurs in *Rana*.

Unless the anterior head of the semitendinosus is to be regarded as its equivalent, there is no *Sartorius* muscle. It is important to notice that in the absence of a sartorius and in the superficial semitendinosus, *Megalophrys* not merely differs from *Rana* but agrees with *Pipa**.

§ *The Lungs and the "Diaphragm."*

The *Lungs* of this species are not much less in size than those of the huge female *Rana guppyi*. The suspensory ligaments appear, however, to be rather different and more complex. I shall give some account of them rather as a basis for future comparison, since but little seems to be known concerning these and other peritoneal folds among the Batrachia. Anteriorly the right lung is not in actual contact with the right lobe of the liver; there is a definite and rather broad pulmo-hepatic ligament, such as is plain in *Rana guppyi*. This ligament runs back and at the end of the liver-lobe becomes continuous with the postcaval vein. It is more extensive than as well as rather different from the corresponding ligament in *Rana guppyi*, and, as will be seen presently, extends much further along the lung. This pulmo-hepatic and afterwards pulmo-caval ligament is attached to the edge of the lung mesiad. It does not end posteriorly in a crescentic free edge as such ligaments often do. It runs as far as the beginning of the kidney and then bends round and becomes continuous with a ligament attaching the dorsal surface of the lung to the oviducal ligament and so to the dorsal body-wall. There is thus a continuous U-shaped line of attachment, and this traverses the lung nearly from end to end. There is thus a similarity to the conditions observable in most Lizards where there is both a pulmo-hepatic and a dorsal pulmonary ligament. "It may be noted," observed Mr. Butler, who first contrasted † the Teiidae, which do not possess the pulmo-hepatic,

* P. Z. S. 1895, p. 838.

† P. Z. S. 1889, p. 465 footnote.

with other Lizards which do, "that two similar types occur among the Amphibia. Thus in the Salamander all the membranous attachments of the lungs and liver seem to be precisely similar to those in the common Lacertilian type (e. g. *Lacerta*). But in the Frog the two lungs hang freely suspended on either side, as in the Teiidae." This is clearly not true of *Megalophrys nasuta*. But it is very nearly true of *Rana guppyi*, but not quite true.

In the latter Frog in fact the pulmonary ligaments, which are illustrated in the accompanying drawing (text-fig. 99, p. 349), have the following disposition and attachments. I have examined three examples of this species and all of them females, and the structure of the parts in question only differs slightly from individual to individual. By far the greater part of the right lung hangs freely in the body-cavity, without any attachments to neighbouring viscera or to the parietes. The difference in this particular between *Rana* and *Megalophrys* is quite striking. Towards the root of the lung a ligament runs obliquely across that viscus; it is at first attached to the right lobe of the liver and runs on to the post-caval vein. The arrangement in fact is so far exactly as in *Megalophrys*. But in the latter the line of attachment of this ligament is along the longitudinal axis of the lung, whereas in *Megalophrys* it is more across and at right angles to this axis. Otherwise, and save in the limited extent of the ligament, the two agree essentially in the mode of suspension of the right lung within the body-cavity. The ligament curves down in the same way as in *Megalophrys*, and is connected with the suspensory ligament of the oviduct. The left lung shows the same relative differences. In *Megalophrys* it has a very long line of attachment to the stomach, while this is not the case with *Rana*. In view, therefore, of these differences, it is important to compare this genus with its undoubted ally *Pelobates*. In the latter Frog the ligament attached to the lung extends for more than half-way down that viscus in its contracted condition, and reaches as far back as the liver in its opposite attachment. Thus there is no doubt the Frog which I describe here is more nearly allied in this particular also to *Pelobates* than it is to *Rana*. And there are other likenesses between these genera in addition to those already made use of by systematists.

In the case of *Pipa* and *Xenopus*, the anatomy of which has been recently studied by myself*, and ten years later by Dr. Keith†, there are muscles which attach the lungs to the parietes. A portion of this complex "diaphragm" is also to be found in the Common Frog, where it consists of a sheet of muscle, a part of the transversalis which ends upon the œsophagus and the roots of the lungs. This has been figured in several places, and the most recent figure known to me is in the latest edition of Ecker's great work

* *Pipa* in P. Z. S. 1895, p. 827, and *Xenopus*, *ibid.* p. 841.

† "The Nature of the Mammalian Diaphragm &c.," J. Anat. Phys. xxxix. 1905, p. 253.

upon the anatomy of the Frog*. In this figure the muscle is seen when the frog is examined as lying upon the dorsal surface to rise gradually from the muscular parietes and to end upon the œsophagus near to its dorsal side. It is a strap-shaped, quite flat band of muscle.

In *Rana tigrina*, where I have examined the muscle carefully, and which is a larger species and thus lends itself more successfully to such an examination, the muscle is very obvious and precisely as in *R. esculenta*. Its fibres can easily be seen to end upon the œsophagus. I could not, however, detect the fact—if it be a fact—that some of these fibres cross the œsophagus to be inserted upon the dorsal face of the lung (or rather, of course, its peritoneal sheath). On the other hand, a portion of the muscle in question is inserted upon the cervical aponeurosis, which lies in front of the lungs and heart and shuts off the neck from the trunk. These muscle-fibres pass into the aponeurosis, and may well be attached to the lung ventrally, since they appear to reach the pericardium beyond it.

The large *Rana guppyi* shows an interesting deviation from these diaphragmatic structures in *Rana tigrina*, which I do not think is entirely a matter of greater clearness of visibility owing to its much larger size. It is, as I believe, to be put down rather to the greater complexity in the detailed structure of animals of a large size as compared with their smaller allies. In this Frog the transversalis muscle is precisely as in *Rana tigrina*, save for the fact that two considerable bands of fibres at no great distance from each other raise themselves from the common mass of the transversalis and pass just under the oviduct to the aponeurosis of the lung. It seems to me to be plain that these detached slips correspond to that portion of the corresponding muscle (with a different origin however) which in *Pipa* and *Xenopus* are very conspicuously attached to the lung, as is shown in the figures of Dr. Keith † and myself ‡. Except in size and importance there is thus less difference between *Rana* (at any rate so far as concerns *R. guppyi*) and *Xenopus* and *Pipa* as regards the insertion of the “spinal segment of the diaphragm” than might have been inferred. As has been pointed out by Dr. Keith, the dorsal part of the “diaphragm” in *Xenopus* has migrated back §—so at least it would seem—to the ilium from which it arises, and in *Pipa* further back still, *i.e.* to the femur, whence the muscle in question springs in that genus. I have, however, now to record some new facts which tend to throw a doubt upon this interpretation of Dr. Keith.

In *Megalophrys* the transversalis sheet to the œsophagus is a muscle of very great extent; it is, for instance, fully twice the length (not relatively, but actually) of the same muscle in *Rana*

* ‘Anatomie des Frosches,’ by Gaupp.

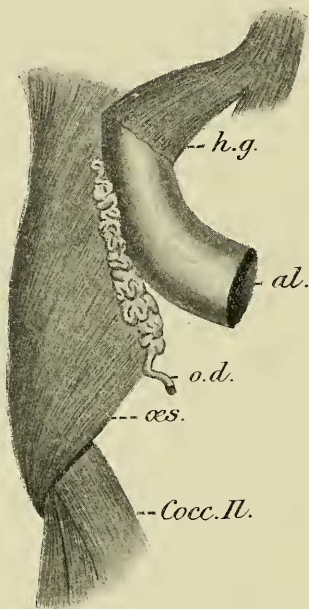
† *Loc. cit.* fig. 10, p. 254, & fig. 11, p. 255.

‡ *Loc. cit.* fig. 1, p. 842.

§ These facts were also correctly noted by myself.

guppyi. It follows, therefore, that as the general build of these two Frogs, *i. e.* the proportions of the skeleton, is much the same, the origin of the muscle in *Megalophrys* must differ from that of *Rana*. And, as a matter of fact, it does. In *Megalophrys* the muscle runs back into quite the pelvic region, and its posterior part arises actually from the ilium. In respect of this muscle, therefore, *Megalophrys* offers us actually what is a theoretically possible condition in the ancestor of both *Rana* and *Xenopus*. Of a continuous sheet of muscle such as occurs in *Megalophrys*, the anterior part only has been retained in *Rana* and the posterior

Text-fig. 98.



The œsophageal sheet of transversalis muscle in *Megalophrys nasuta*.

al. Œsophagus. *Cocc.II.* Coccygeo-iliacus muscle. *h.g.* Hyoglossus. *o.d.* Oviduct.
cs. Œsophageal muscle.

part only in *Xenopus*. A careful examination of this muscle in *Megalophrys* has convinced me that no fibres escape from it on to the lung or any other viscera. Its attachment to the œsophagus, and to the œsophagus only, can be easily followed. The oviducal membrane which it underlies is clear and transparent throughout, with no muscular fibres traversing it.

In view of the interesting differences which the transversalis muscle of *Megalophrys* shows to the corresponding muscle of the

other genera of Batrachia described above, I am particularly glad to have had the opportunity of dissecting, and to be able to record the appearance of, the muscles of this region of the "thorax" in *Pelobates fuscus*; for this genus is referred by Boulenger to the same family, Pelobatidæ, as that which contains *Megalophrys*. That Boulenger's view is more correct than that of Mivart* and some others, is testified to by the structures of these various muscular arrangements which have been considered in the foregoing pages. The figure (text-fig. 95, p. 334) is a drawing of the interior of the body of a male *Pelobates fuscus*, with such viscera removed as interfere with the proper view of the transversalis muscle. It will be noted that that muscle is very extensively developed and that its origin reaches back not only to the ilium, but for some way along that bone, where it overlaps, but hardly conceals, the coccygeo-iliacus.

The whole of the transversalis muscle in *Pelobates* is obviously fixed to the œsophagus, in which there is a slight difference from *Megalophrys*, where the hinder end of the muscle does not appear to reach the œsophagus but to terminate upon the oviducal membrane. The *Pelobates* however, as I have mentioned, was a male; but the corresponding part of the muscle were it present would naturally lie upon the median mesentery. The muscle is, moreover, at first sight rather reduced in size as compared with that of *Megalophrys*. But a close study shows that this is due to the semilunar excavation of the posterior margin of the same,—that really its origin extends quite as far back as in *Megalophrys*. Moreover, in both of these Frogs the muscle completely covers and conceals the ilio-costal muscles; anteriorly a state of affairs which is not found in *Rana* &c., as is depicted in the accompanying figure (text-fig. 98). In *Pelobates* the distinction between this muscle and that which is applied to the terminal cervical aponeurosis is very marked; their fibres do not show any continuity anywhere. This muscle—the ventral part of the diaphragm, as Dr. Keith terms it—is better developed in *Pelobates* than in *Rana*. There is hardly any membranous portion left. This is plainly shown in the figure.

I have also examined into the condition of this œsophageal sheet of the transversalis in other genera. In the South American *Ceratophrys ornata* the muscle is easy to see and is disposed rather differently from the muscle in the genera that have been already referred to. It is not extensive as in *Megalophrys*; but is, as in *Rana*, limited to the fore part of the visceral cavity. Instead of forming at its origin at any rate a single continuous sheet of muscle, it is in *Ceratophrys* distinctly divided into three portions. The present is one of the species of the genus which possesses a large dorsal ossification in the cutis, which is firmly articulated to the vertebral transverse process, from the surface of which the muscles in question arise. The innermost or posterior of the three

* "The Classification of the Anurous Batrachians," P. Z. S. 1869, p. 290 &c.

slips (on the right side of the body) is the one which is attached to the œsophagus. It is, as already said, short as in *Rana*, and does not extend far back in the body. The middle slip partly covers this and is of considerably less size, that is to say, breadth, for the length hardly differs. It lies at a different plane from the first slip of the entire muscle, being more ventrally directed in its course. It is attached to the membrane bearing the oviduct, which is in its turn connected with the membrane at the root of the lung. The outermost portion of the muscle is the largest and is chiefly spread over the cervical aponeurosis, a good many of its fibres being directed towards the lung. On the left side of the body of the example of this species which I dissected, there was not quite so marked a distinction between the first two parts of the muscle. There is thus in this species of Frog a very much more marked subdivision of the muscle than exists in *Rana guppyi*, which is perhaps due to, and is at least connected with, the fact that the origin of the muscle in *Ceratophrys* is more spread over the surface of the transverse process, which is moreover enlarged and rather firmly connected with the dorsal scute. This transverse process extends outward far beyond the transverse processes of the vertebrae which follow it. I am at present unable to go into detail; but a dissection of *Bufo aqua* and of *Rhacophorus** sp., has shown that in these species also there is some specialisation of the slips of muscle passing to the œsophagus and lung.

§ *Alimentary Canal.*

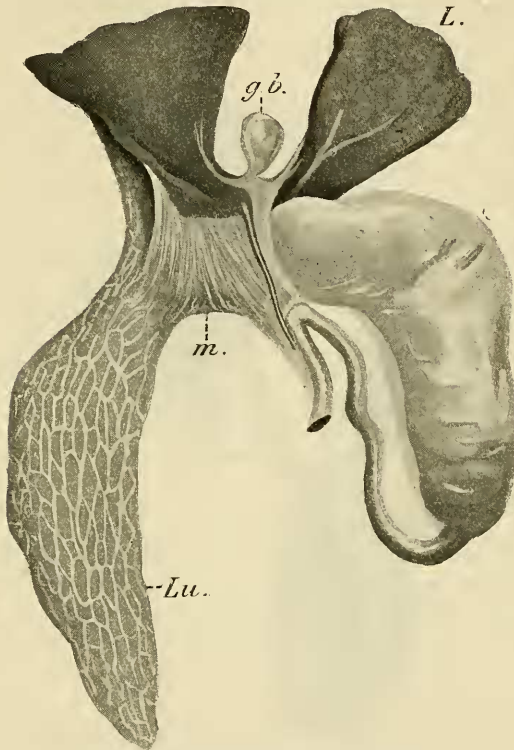
The *alimentary canal* and the *appended glands* of *Megalophrys nasuta* show certain small variations from the structure of those organs in *Rana esculenta* and *R. tigrina*. But the conditions obtaining in *Rana guppyi* (text-fig. 99) prove that the form of the liver, for example, is to be used with caution as a generic character, as do also the variations in the form of this organ in the Common Frog. In *Rana guppyi*, for instance, the two lobes of the liver represent the entire subdivision of that organ. The right and left lobes were not further subdivided in any of the three examples at my disposal. And it may be remarked that three examples selected at random are a very fair test of a characteristic. Moreover, in all of these three specimens the right and left lobes were of approximately the same size. They were connected below the œsophagus by a narrow isthmus of hepatic tissue. Now in the Common Frogs of this country the left lobe is decidedly the larger of the two. In the example of *Rana tigrina* which I dissected the outer of the two lobes of the left division of the liver was, though only slightly, the larger; it is the same lobe which is figured as the larger in *Rana esculenta*†. *Megalophrys* agrees with *Rana esculenta* and *R. tigrina* as to the general disposition of the liver-

* From Borneo. I owe this specimen also to the kindness of Dr. Charles Hose.

† Cf., e.g., 'The Anatomy of the Frog' by Ecker, Engl. trans. by Haslam: Oxford, 1889, p. 295, fig. 194 L.

lobes. The left is very much the larger of the two, and it is subdivided into two lobes of unequal size of which the outer, situated more ventrally, is the larger *. In *Pelobates fuscus* the right half of the liver is the smaller; the left lobe is also (as in *Megalophrys*) composed of two very distinct lobes of approximately equal size, the inner however being in this case rather the larger. The *pancreas* of both *Megalophrys* and *Pelobates* differs from that of *Rana* as

Text-fig. 99.

Liver and adjacent viscera of *Rana guppyi*.

g.b. Gall-bladder. *L.* Liver. *Lu.* Lung. *m.* Mesentery attaching liver to lung &c.

figured by many authors. Its lowest portion is massive in these two genera; but, whereas in *Pelobates* this region of the pancreas is firmly attached to the stomach, it is attached to the duodenum in *Megalophrys*. The separation of the stomach from the duodenum

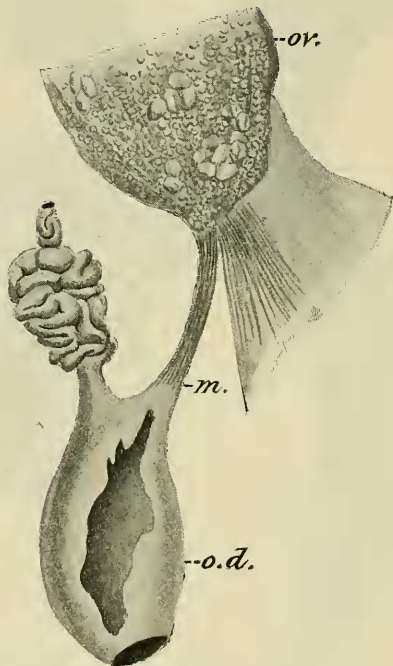
* Dumeril & Bibron, 'Erpétologie Générale,' t. viii. p. 456, remark also (of *M. montana*) that the right lobe is but slightly developed and that the left is divided into two.

is more marked in *Megalophrys* than in either *Pelobates* or *Rana*. The pylorus is situated a little way beyond the lowest point of the U formed by the stomach and the duodenum and is marked externally by a raised annular fold.

§ *Ovaries and Oviducts.*

The whole abdominal cavity of this Frog was filled with eggs which were not contained within the oviducts, but in the ovaries themselves. The lobes of the ovary packed tightly with ripe ova, among which were immature ova, were polygonal through mutual

Text-fig. 100.



Oviduct of *Megalophrys nasuta*.

o.d., Dilated lower part of oviduct. *ov.*, Ovary. *m.*, Muscular band attaching ovary to cæcum of oviduct.

pressure. The mesovarium which joins the mesocolon is remarkable for the fact that posteriorly its margin is strengthened by a thick and strong band of muscular fibres. I could not observe any structure of this kind in *Rana guppyi* in the same region. This band of muscles in *Megalophrys* is shown in the accompanying figure (text-fig. 100). It will be there seen that it is broken up into wider and narrower strands of muscle, which are partly con-

tained within or lie upon the mesovarium and thus run towards the median dorsal line of the body, and are partly inserted upon the distal dilated sac in which the oviduct ends (as in *Rana* &c.), and by which it opens into the cloaca.

Traced in the opposite direction, the fibres soon lose themselves upon the ovary. The strand of muscles which is inserted upon the terminal chamber of the oviduct is much the thickest. It was, however, not absolutely accurate to speak of this band of muscular fibres as being inserted upon the dilated posterior chamber of the oviduct. They are really inserted upon a distinct and rather tubular diverticulum of the same, which lies to the inside of the oviduct and naturally points towards the ovary. This diverticulum is certainly totally absent in *Rana guppyi*, where—considering the size of the Frog—it would be easy to detect were it present. The band of muscles continuing on this diverticulum to the ovary associates it particularly with the gonad. The association might be physiological as well as anatomical. For a swelling of the ovaries would tend to fall upon the diverticulum of the uterus, possibly thus stimulating its growth and that of the uterus at the time when it is required to be large for the reception of the ova.

On the left side of the body the structure of the various bands of muscle and the diverticulum of the uterus was not absolutely identical. In fact, there was no appearance of a stout band of muscle applied to the diverticulum of the uterus, only fine fibres in the mesovarium. Nor was the diverticulum so conspicuously marked as on the right side. The two uteri join just before they open into the cloaca on a marked papilla by a single orifice, as in some genera.

The internal orifice of the oviduct in this Frog has a position which differs rather from that of the oviducal aperture of *Rana guppyi*. In the latter it is distinctly to the outside of the lung; in my species it is situated as distinctly to the inside of the lung base. In both cases this funnel-shaped expansion lies upon the ligament attaching the liver to the anterior wall of the abdominal cavity.

§ Summary of Principal New Facts.

It will be convenient to briefly summarise the chief new facts contained in the preceding pages. They are as follows:—

(1) The genera of the family Pelobatidæ should perhaps be increased by the addition of one for a Bornean species, possibly identical with *Megalophrys nasuta* (auct.), which differs from all other genera of that family in certain features.

(2) This species agrees with *Pelobates* (? as to other Pelobatidæ) and differs from *Rana*, *Ceratophrys*, and some other genera, in the great extent of the visceral layer of the transversalis muscle ("diaphragm"), which is attached along a greater length of the pharynx and arises from the transverse processes of several vertebrae and from the ilium for a long way down, covering over and

completely concealing the ilio-lumbaris muscle, which is entirely exposed in the other genera mentioned.

(3) The equivalent muscle of *Ceratophrys*, though arising as in *Rana* and other genera from the transverse process of the fourth vertebra only, is specialised into three separate slips, supplying respectively the pharynx, lung, and cervical aponeurosis. This specialisation of the muscle is also to be seen in *Rhachophorus* and *Rana guppyi*.

(4) In *Megalophrys nasuta* the sacral vertebra is single and fused with the coccyx and the vertebrae are procelous.

(5) The hyoid in this Frog agrees with that of the Pelobatidæ generally in the deficient development of the anterior cornua. These are only represented by a ligament, and the hyoid as a whole most closely resembles that of *Xenophrys monticola* as figured by W. K. Parker. The musculature of the hyoid does not materially differ from that of *Rana*.

(6) The musculature of the back shows characteristic differences among different genera of Batrachians. The genera of Ranidæ and Cystignathidæ and Bufonidæ examined show fewer differences among themselves than any of them do from the Pelobatidæ, *Pelobates* and *Megalophrys nasuta*.

(7) In the last two is a peculiar muscle apparently belonging to the ilio-lumbar complex, running from the middle of the ilium directly to the transverse process of the second vertebra, which may perhaps be the equivalent of the "Musculus pulmonum proprius" of *Pipa*. Other comparisons between the muscular system of *Megalophrys nasuta* are remarked upon in the present paper; and other authors have commented upon likenesses between the Aglossa and the Pelobatidæ.

4. Contributions to the Osteology of Birds.—Part IX. *Tyranni*; *Hirundines*; *Muscicapæ*, *Lani*, and *Gymnorhines*. By W. P. PYCRAFT, F.Z.S., A.L.S., &c.

[Received March 18, 1907.]

(Text-figures 101–104.)

CONTENTS.

i. Introductory Remarks, p. 352.	vi. The Pelvic Girdle, p. 369.
ii. The Skull of the Adult, p. 353.	vii. The Pectoral Limb, p. 370.
iii. The Vertebral Column, p. 366.	viii. The Pelvic Limb, p. 371.
iv. The Ribs, p. 367.	ix. Summary, p. 372.
v. The Sternum and Shoulder-Girdle, p. 367.	x. Key to the Osteological Characters of the Skull, p. 378.

i. INTRODUCTORY REMARKS.

Although it cannot be claimed for the following pages that they contain a complete account of the osteology of the several groups enumerated above, they may at least be said to contain